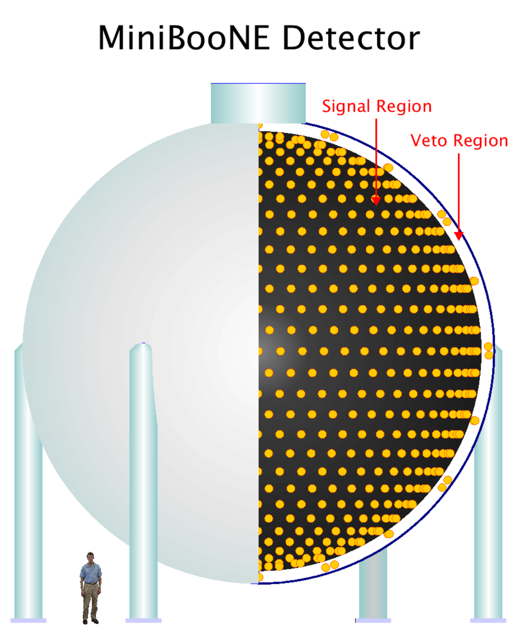
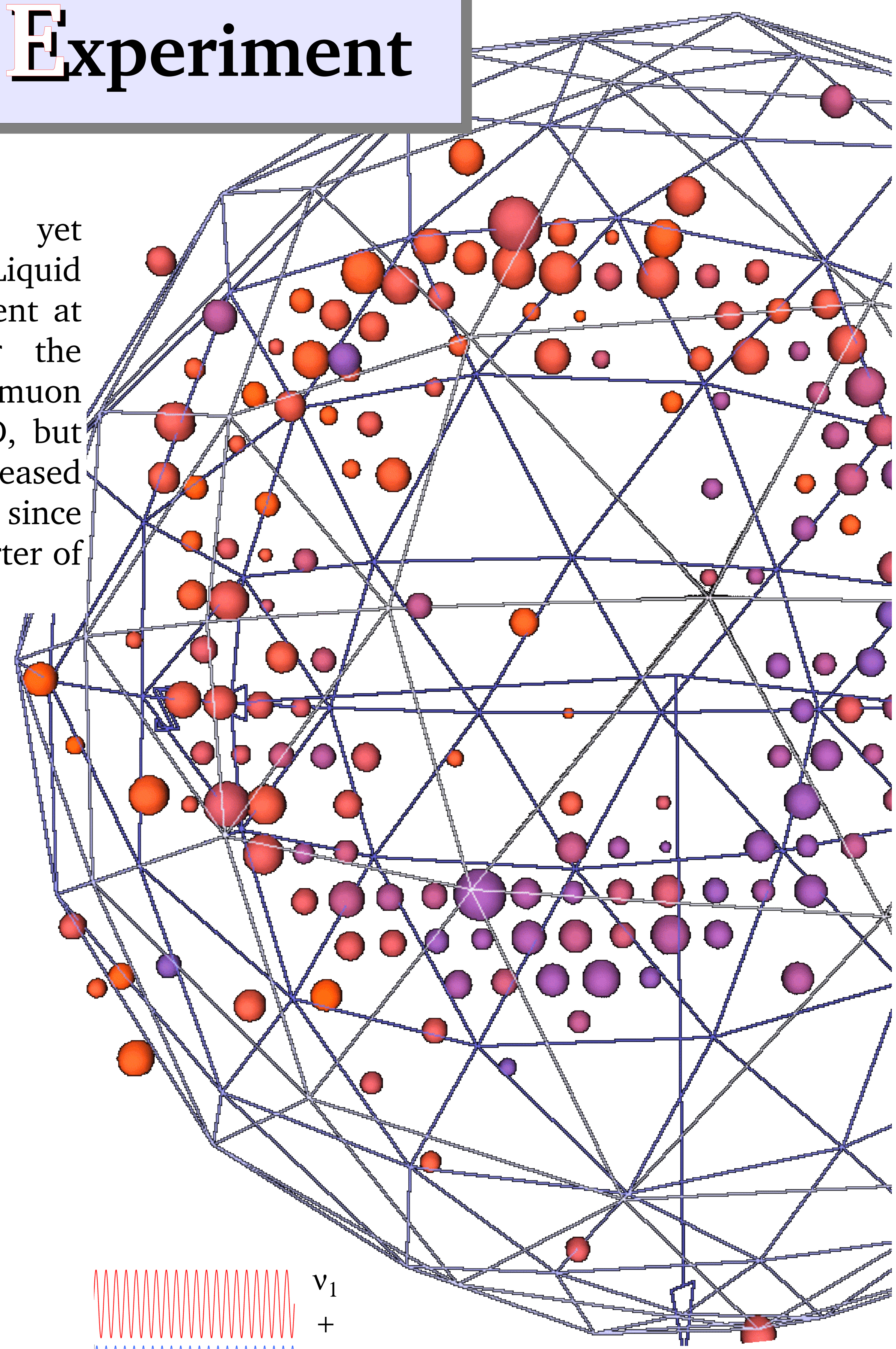
# The Mini BooSter Neutrino Experiment




MiniBooNE is designed to address the yet unconfirmed oscillation signal seen by the Liquid Scintillator Neutrino Detector (LSND) experiment at Los Alamos. MiniBooNE will search for the appearance of electron neutrinos in a beam of muon neutrinos with an L/E similar to that of LSND, but with substantially differing systematics and increased statistics. MiniBooNE has been recording data since September, 2002, and has collected over a quarter of a million neutrino events to date.

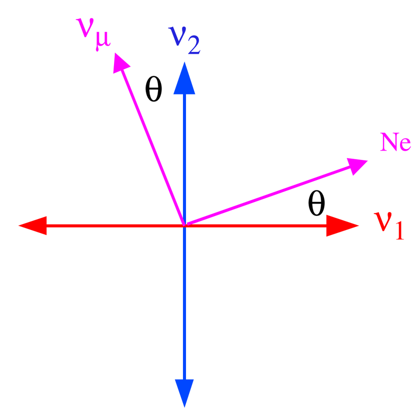


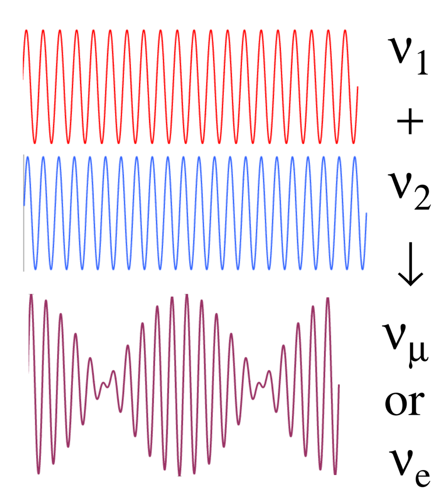
## Neutrino Oscillations and the LSND Signal

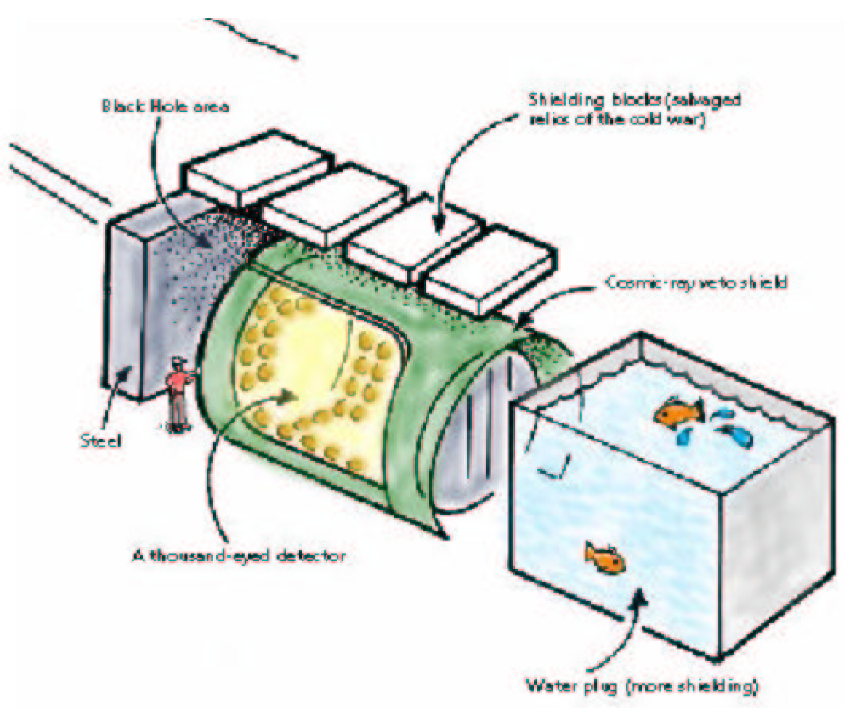
Experimental results have indicated that neutrinos are indeed massive particles and that the more familiar weak eigenstates of the neutrino $(\nu_e, \nu_\mu, \nu_\tau)$ are actually mixtures of mass eigenstates $(\nu_1, \nu_2, \nu_3)$. If the typical 3 generation model is simplified to two neutrinos, then this mixing, and thus the oscillation probability, can be written in a simple form where $\theta$ represents the level of mixing between these states, $\Delta m^2 \equiv m_2^2 - m_1^2$. L and E are experimental parameters; the baseline from target to detector and the neutrino energy, respectively.

$$\begin{pmatrix} \nu_\mu \\ \nu_e \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \end{pmatrix}$$

$$Prob(\nu_\mu \to \nu_e) = \sin^2 2\theta \sin^2\left(\frac{1.27\Delta m^2(eV^2)L(km)}{E(GeV)}\right)$$



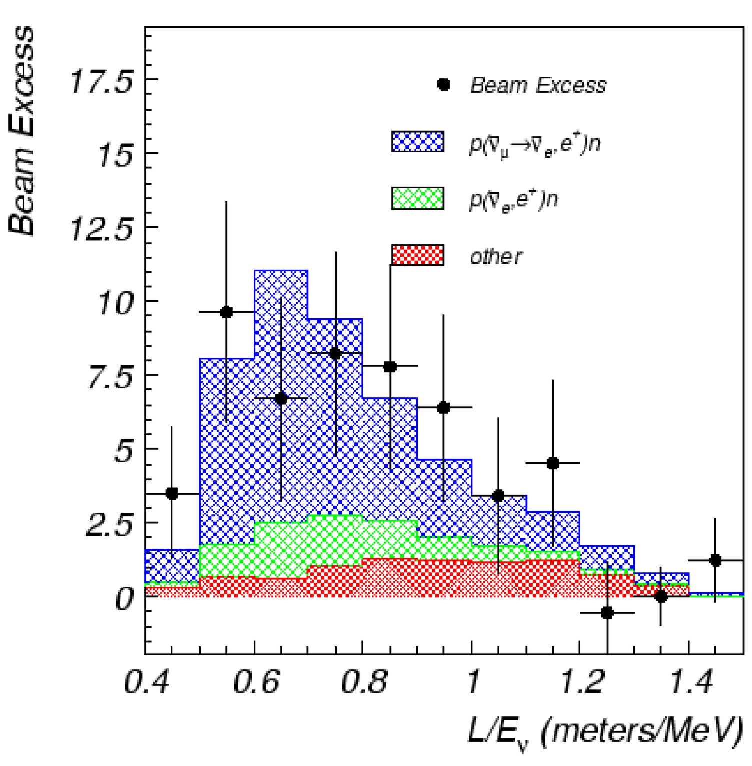



LSND was an accelerator-based $\overline{\nu}_\mu \to \overline{\nu}_e$ oscillation search at Los Alamos National Laboratory in New Mexico. An 800 MeV beam of protons was produced by the LANSCE accelerator and directed to a water target, producing pions. These pions traveled to a copper beam stop where $\pi^-$ were captured, and $\pi^+$ were brought to rest and decayed into muons which subsequently also decayed.

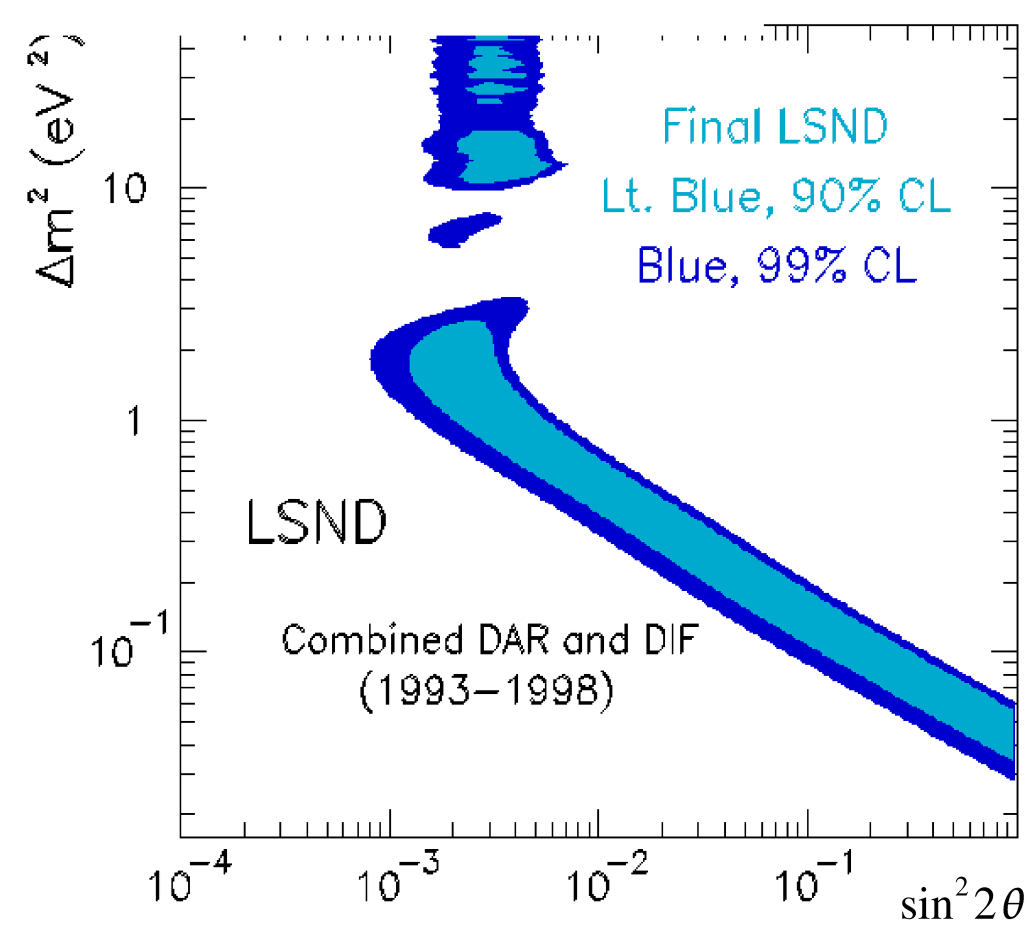
$$\pi^+ \to \mu^+ + \nu_\mu$$
$$\hookrightarrow e^+ + \nu_e + \overline{\nu}_\mu \xrightarrow{?} \overline{\nu}_e$$

No $\overline{\nu}_e$ were produced in the decay chain; LSND searched for their appearance in a cylindrical detector filled with 167 tons of liquid scintillator and lined with 1220 photomultiplier tubes.




LSND saw an excess of $\overline{\nu}_e$ events in their detector. **89.7 +- 22.4 +- 6.0** of them to be precise. This implies a $\overline{\nu}_\mu \to \overline{\nu}_e$ oscillation probability of:

$$\mathbf{P(\overline{\nu}_\mu \to \overline{\nu}_e) = (0.264 \pm 0.067 \pm 0.045)\%}$$

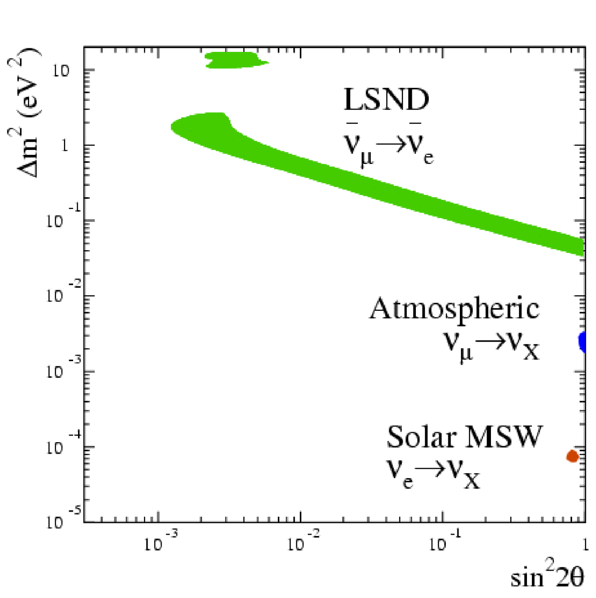



LSND's oscillation probability is consistent with high $\Delta m^2$ oscillations.

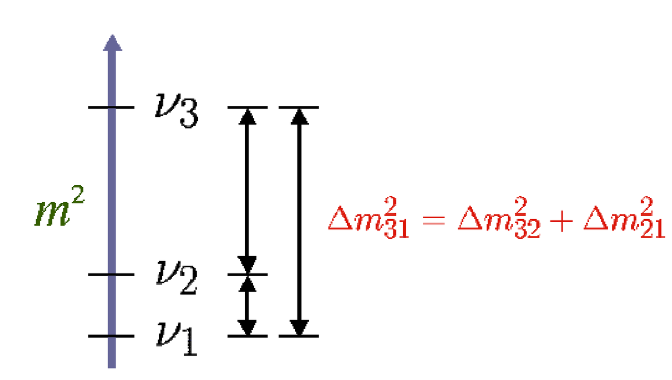
## New Physics?

The LSND result, when combined with the oscillation results of atmospheric and solar neutrino experiments implies physics beyond minimal extensions of the Standard Model. Should MiniBooNE rule out the LSND signal, then the conventional 3-neutrino model will remain intact. However, should MiniBooNE see oscillations consistent with those of LSND, the implications on the Standard Model are very exciting. There are several ideas.........

### Sterile Neutrinos



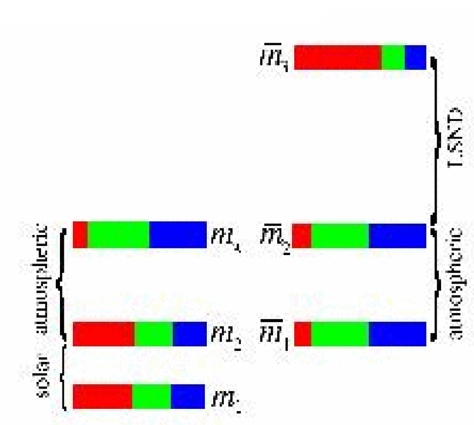

3 independent $\Delta m^2$ values cannot be accommodated by 3 massive neutrinos. This implies the existence of additional, non-weakly interacting neutrinos. i.e. Sterile neutrinos.




but, $\Delta m^2_{LSND} \neq \Delta m^2_{atm} + \Delta m^2_{solar}$ !!

### CPT Violation

If neutrinos and anti-neutrinos have different mass hierarchies and/or mixings, it would imply CPT violation. MiniBooNE has the ability to search for this by reversing the horn polarity and running with an anti-neutrino beam.




Or Perhaps Something Else?